Library Copy
RA A22 L280

UNCLASSIFIED

[redacted]

Copy 43
RM SL56A20

NACA

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

AERODYNAMIC CHARACTERISTICS AT MACH NUMBERS OF 1.61 AND 2.01 OF VARIOUS TIP CONTROLS ON THE WING PANEL OF A 0.05-SCALE MODEL OF A MARTIN XASM-N-7 (BULLPUP) MISSILE

TED NO. NACA AD 3106

By Cornelius Driver

Langley Aeronautical Laboratory
Langley Field, Va.

UNCLASSIFIED

CLASSIFICATION CHANGED

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
WASHINGTON

[redacted]

UNCLASSIFIED

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

AERODYNAMIC CHARACTERISTICS AT MACH NUMBERS OF 1.61 AND 2.01 OF VARIOUS TIP CONTROLS ON THE WING PANEL OF A 0.05-SCALE MODEL OF A MARTIN XASM-N-7 (BULLPUP) MISSILE

TED NO. NACA AD 3106

By Cornelius Driver

SUMMARY

An investigation has been conducted in the Langley 4- by 4-foot supersonic pressure tunnel to determine the control effectiveness and hinge-moment characteristics of the Martin XASM-N-7 (Bullpup) missile. A half-scale wing panel was tested with a tip control having three different hinge-line locations. The tests were made over an angle-of-attack range from -10° to 10° and a control-deflection range of -15° to 3°. The present paper is a data presentation of the results obtained at Mach numbers of 1.61 and 2.01.

INTRODUCTION

At the request of the Bureau of Aeronautics, Department of the Navy, an investigation has been conducted in the Langley 4- by 4-foot supersonic pressure tunnel to determine the control effectiveness and hinge-moment characteristics of the Martin XASM-N-7 (Bullpup) missile. The missile uses a system of gyro-activated ailerons (rollerons) to inhibit the rate of roll. Simulated rollerons were tested on a half-scale delta-wing panel in the presence of a dummy body. The rollerons were tested with a simulated nonrotating gyro wheel both on and off. Three different balance-to-control ratios were obtained by means of varying the hinge-line location of the control. This paper is a data presentation of the results obtained at Mach numbers of 1.61 and 2.01.

SYMBOLS

The data are referred to the stability axis system (fig. 1) with the center of moments at 37.2 percent of the exposed wing root chord.

S	wing area (total = 90.01 sq in.)
$\bar{c}$	wing mean aerodynamic chord (10.796 in.)
M_a	moment area of control surface aft of hinge line
M	Mach number
q	dynamic pressure
α	angle of attack, deg
δ_a	control deflection relative to wing (positive trailing edge down on right wing panel), deg
L	force along the Z-axis
D	force along the X-axis
M'	moment about the Y-axis
M_x	moment about the X-axis
M_h	moment about the control hinge line
C_L	lift coefficient, $\frac{L}{qS}$
C_D	drag coefficient, $\frac{D}{qS}$
C_m	pitching-moment coefficient, $\frac{M'}{qS\bar{c}}$
C_l	rolling-moment coefficient, $\frac{M_x}{qSb}$
C_h	hinge-moment coefficient, $\frac{M_h}{2qM_a}$

TEST CONDITIONS AND PROCEDURES

The tests were made at Mach numbers of 1.61 and 2.01, a stagnation pressure of 13 pounds per square inch absolute, and a stagnation temperature of 100° F. The dewpoint was maintained sufficiently low (below -25° F) so that no condensation effects were encountered.

The Reynolds number based on a mean aerodynamic chord of 0.899 foot was 3.34×10^6 at $M = 1.61$ and 2.88×10^6 at $M = 2.01$.

The wing angle-of-attack range was from -10° to 10° and the control deflection range relative to the wing was from -15° to 3°.

COEFFICIENTS AND ACCURACY

The angle-of-attack and control-deflection data have been corrected for deflections caused by the aerodynamic loads. The angles of attack and control deflection are estimated to be accurate within ±0.1°. The Mach number variation in the test section was approximately ±0.01.

The estimated errors in the individual measured quantities are as follows:

C_L	±0.023
C_D	±0.0016
C_m	±0.005
C_l	±0.007
C_h	±0.0001
α, deg	±0.1
δ_a, deg	±0.1
M	±0.01

MODEL AND APPARATUS

The model used in this investigation consisted of a half-delta wing panel mounted on a cylindrical half-body with an ogival nose. The wing was provided with three interchangeable controls having different hinge-line locations.

A drawing of the model is shown in figure 2. A wing mounting bracket, simulating the attachment plate used on the full-scale missile, was mounted on each surface of the wing as shown in figure 2 for most of the tests. Forces measured on the wing included the forces on the wing attachment plate. The rolleron and flap arrangement showing the various hinge-line locations is shown in figure 3. The geometric characteristics of the model are presented in table I.

The model was tested on a boundary-layer bypass plate as shown in figure 4. The forces and moments on the wing were measured through the use of a four-component strain-gage balance mounted in the turntable of the bypass plate. No forces or moments were measured on the body which was rigidly attached to the turntable. The angle of attack was changed by rotating the turntable, which was motor driven from outside the tunnel.

The hinge moments on the control were determined by means of a strain-gage system which measured the torque exerted at the control hinge line. The angle of attack and the control deflections were set by means of an electrical control position indicator.

PRESENTATION OF RESULTS

The basic results are computed for a stability axis system and are presented as functions of angle of attack α and control deflection δ.

The figures are presented in the following manner:

Figure

DISCUSSION

The variation of the hinge-moment coefficient with rolleron deflection at constant angles of attack (figs. 5, 6, and 7) becomes increasingly nonlinear as the control balance increases from 20 to 36 percent. The variation of the rolling-moment coefficient with rolleron deflection (figs. 5, 6, and 7) is essentially linear and indicates constant rolling effectiveness over the angle-of-attack range.

The variation of the rolleron hinge-moment coefficient with angle of attack (figs. 9, 10, and 11) indicates an abrupt change in slope at $\pm 4^{\circ}$ angle of attack which is probably a result of the shock wave disturbance from the simulated wing attachment plate. The data of figures 9, 10, and 11 indicate that C_{h_α} becomes increasingly nonlinear with increasing control balance. Some improvement in the linearity of C_{h_α} may be expected, however, with the removal of the wing attachment plate (fig. 13).

Attempts to correlate the hinge-moment slope parameters C_{h_δ} and C_{h_α} with the correlations presented in reference 1 for a family of tip controls were unsuccessful. The poor agreement probably resulted because of the differences in geometry between the controls tested. The present controls had the balance area shielded by the wing ahead of the control and had the wing tip cut off parallel to the stream. It appears that in using the correlation of reference 1 for predicting control hinge-moment characteristics that care must be taken that the control not only belongs to the same family of controls but is also similar in geometry.

Calculated values of C_{h_δ} (refs. 2 and 3) and C_{h_α} (refs. 4 and 5) using the linear-theory method also showed poor agreement with the experimental results. In contrast to the theoretical predictions shown in reference 6, linear theory consistently underestimated the experimental hinge-moment slopes for the present tests. It should be pointed out, however, that the data from the present investigation correlate well with the experimental data obtained on a smaller scale model of a similar configuration (ref. 7).

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., January 6, 1956.

Cornelius Driver
Cornelius Driver
Aeronautical Research Scientist

Approved: John V. Becker
John V. Becker
Chief of Compressibility Research Division

mfd

REFERENCES

1. Lord, Douglas R., and Czarnecki, K. R.: Aerodynamic Characteristics of Several Tip Controls on a 60° Delta Wing at a Mach Number of 1.61. NACA RM L54E25, 1954.

2. Coale, Charles W.: Supersonic Characteristics of Rectangular Horn Balanced Ailerons. Rep. No. SM-13718, Douglas Aircraft Co., Inc., Mar. 31, 1950.

3. Lagerstrom, P. A., and Graham, Martha E.: Linearized Theory of Supersonic Control Surfaces. Jour. Aero. Sci., vol. 16, No. 1, Jan. 1949, pp. 31-34.

4. Harmon, Sidney M., and Jeffreys, Isabella: Theoretical Lift and Damping in Roll of Thin Wings With Arbitrary Sweep and Taper at Supersonic Speeds – Supersonic Leading and Trailing Edges. NACA TN 2114, 1950.

5. Martin, John C., Margolis, Kenneth, and Jeffreys, Isabella: Calculation of Lift and Pitching Moments Due to Angle of Attack and Steady Pitching Velocity at Supersonic Speeds for Thin Sweptback Tapered Wings With Streamwise Tips and Supersonic Leading and Trailing Edges. NACA TN 2699, 1952.

6. Czarnecki, K. R., and Lord, Douglas R.: Hinge-Moment Characteristics for Several Tip Controls on a 60° Sweptback Delta Wing at Mach Number 1.61. NACA RM L52K28, 1953.

7. Anon.: The XASM-N-7 Guided Missile Weapon System - Analysis of Test Results, 50 Per Cent Rolleron Wing Panel. ER No. 6449 (Contract No. NOas54-633-c), The Glenn L. Martin Co., Feb. 15, 1955.

TABLE I.- GEOMETRIC CHARACTERISTICS OF MODEL

Wing:	
Airfoil	Hexagonal
Wing span, in.	9.450
Theoretical root chord, in.	15.55
Exposed root chord, in.	11.725
Theoretical M.A.C., in.	10.796
Tip chord, in.	3.500
Theoretical wing area, sq in.	90.01
Thickness, in.	0.3125
Sweep, leading edge, deg	51.9
Aspect ratio	1.984
Taper ratio	0.225
Body:	
Length, in.	36.562
Diameter (max.), in.	6.0
Area (cross section - complete model), sq ft	0.196
Ogive radius (not to scale)	54.0810
Tangent point of ogive (body station not to scale)	17.76
Rollerons:	
20-percent balance:	
Tip chord, in.	1.950
Span, in.	2.45
[1]Total area, sq in.	4.154
Balance area, sq in.	0.830
Hinge-line location (percent tip chord)	30.46
Percent balance	20.0
28-percent balance:	
Tip chord, in.	1.950
Span, in.	2.45
[1]Total area, sq in.	3.95
Balance area, sq in.	1.11
Hinge-line location (percent tip chord)	40.51
Percent balance	28.1
36-percent balance:	
Tip chord, in.	1.950
Span, in.	2.45
[1]Total area, sq in.	3.760
Balance area, sq in.	1.360
Hinge-line location (percent tip chord)	49.64
Percent balance	36.2

[1]Does not include exposed area of wheel, which is 0.218 square inch.

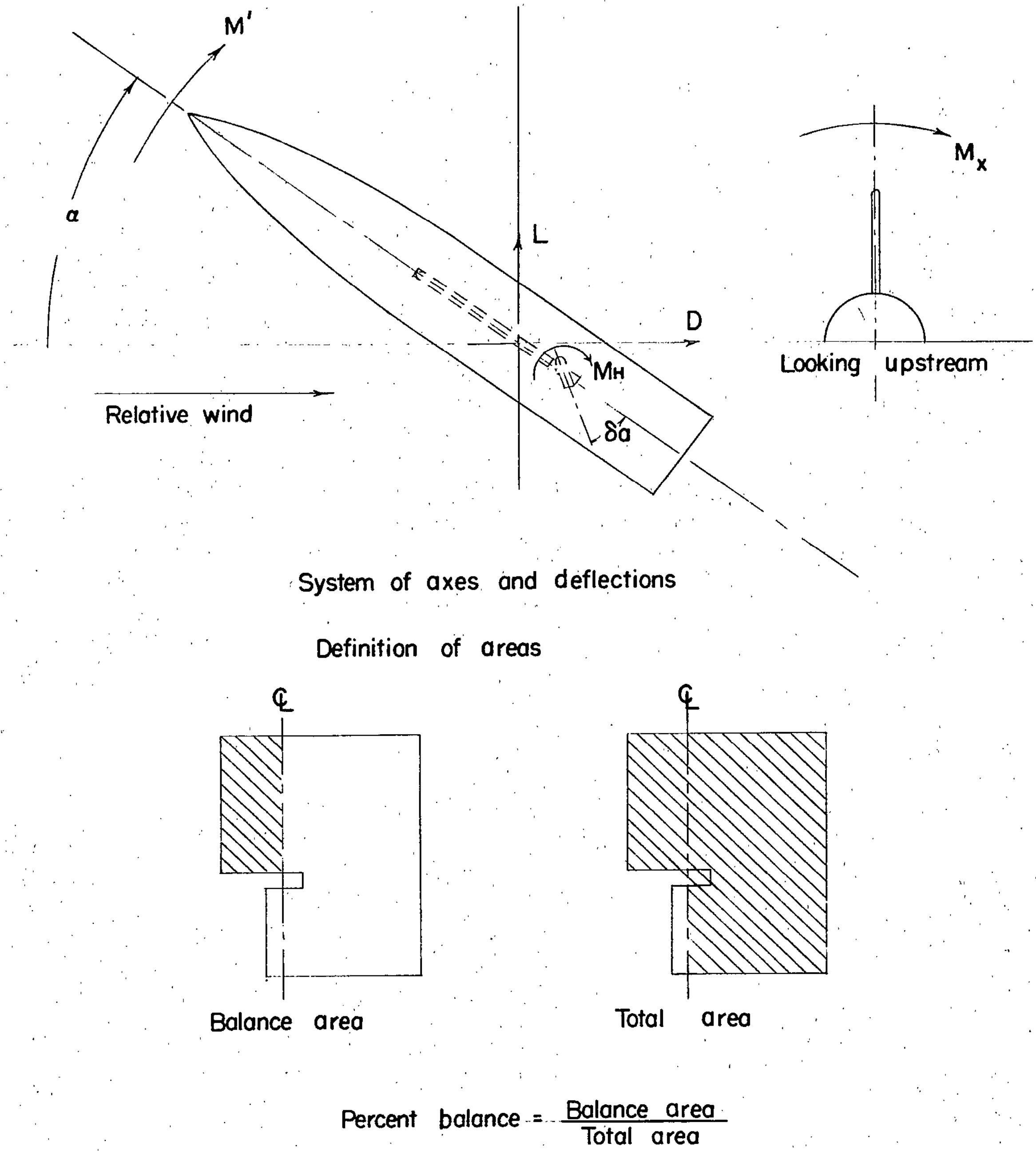


Figure 1.- Definition of axes system and rolleron areas.

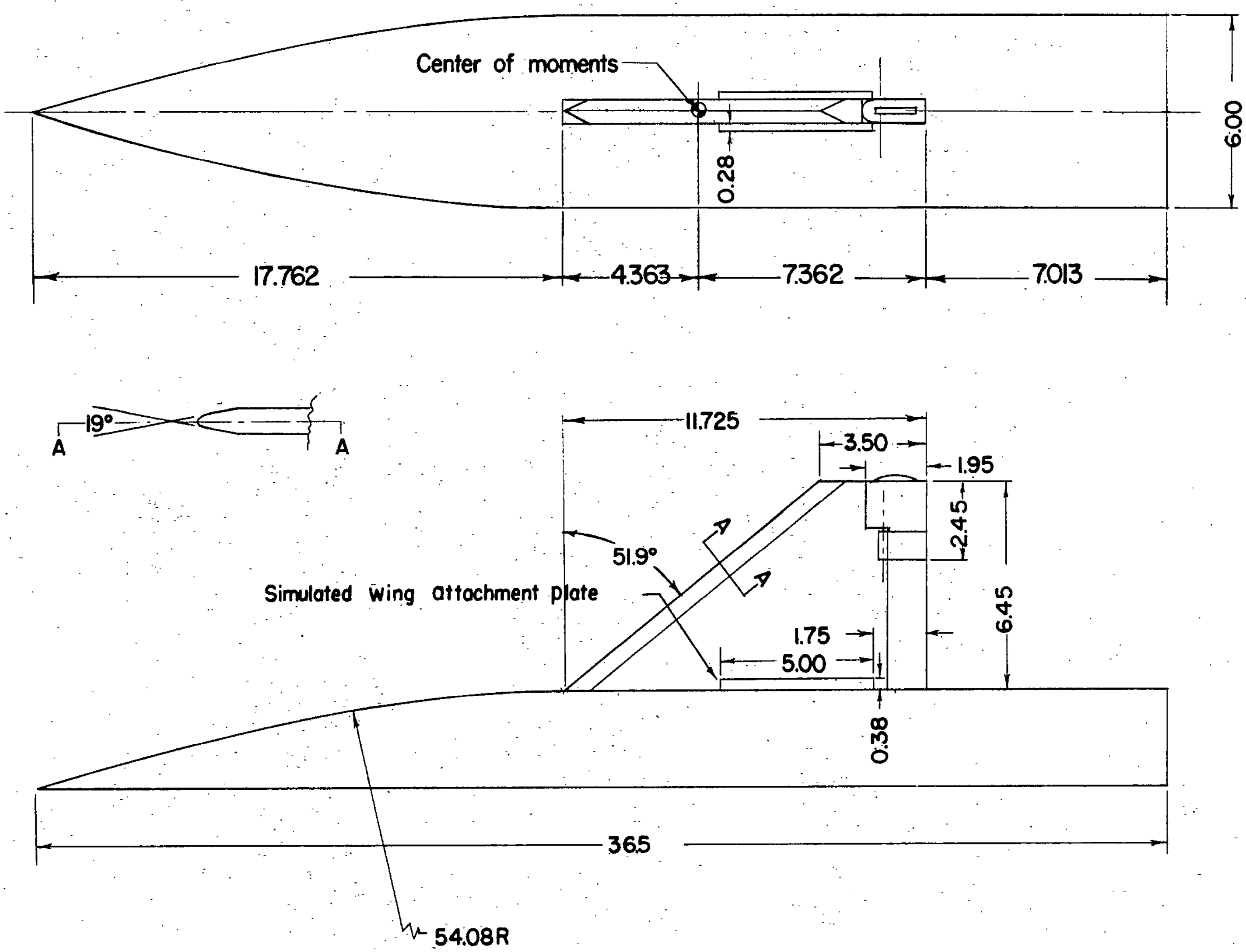
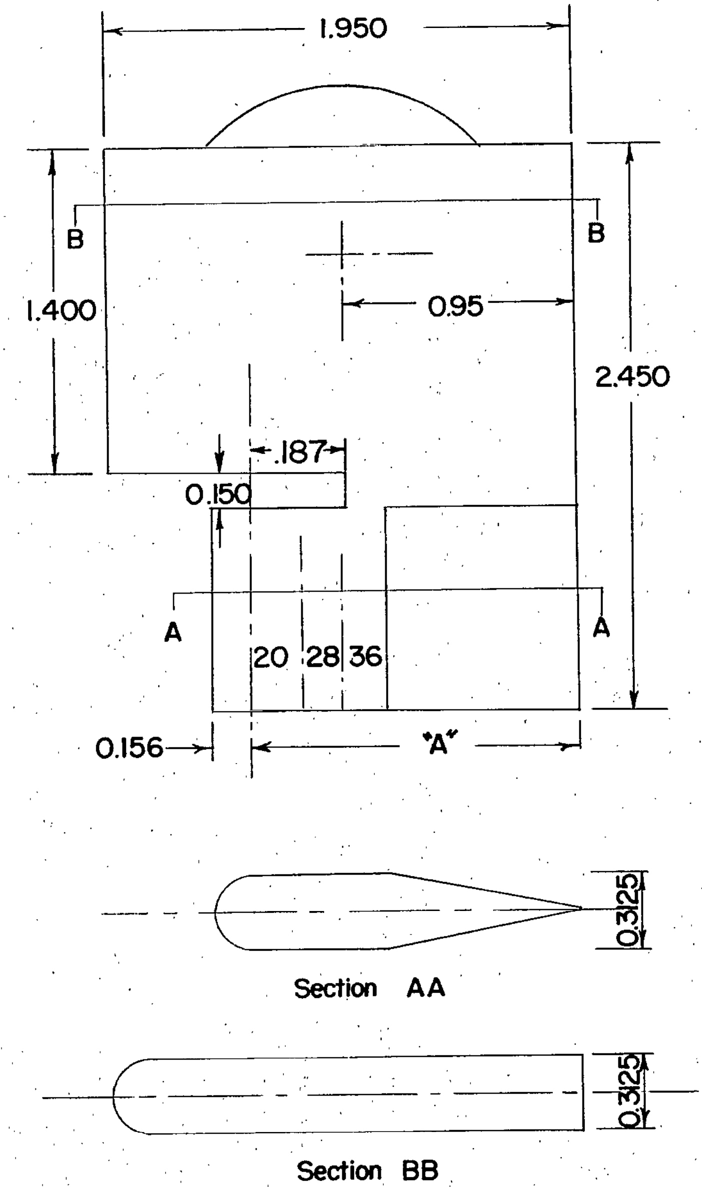


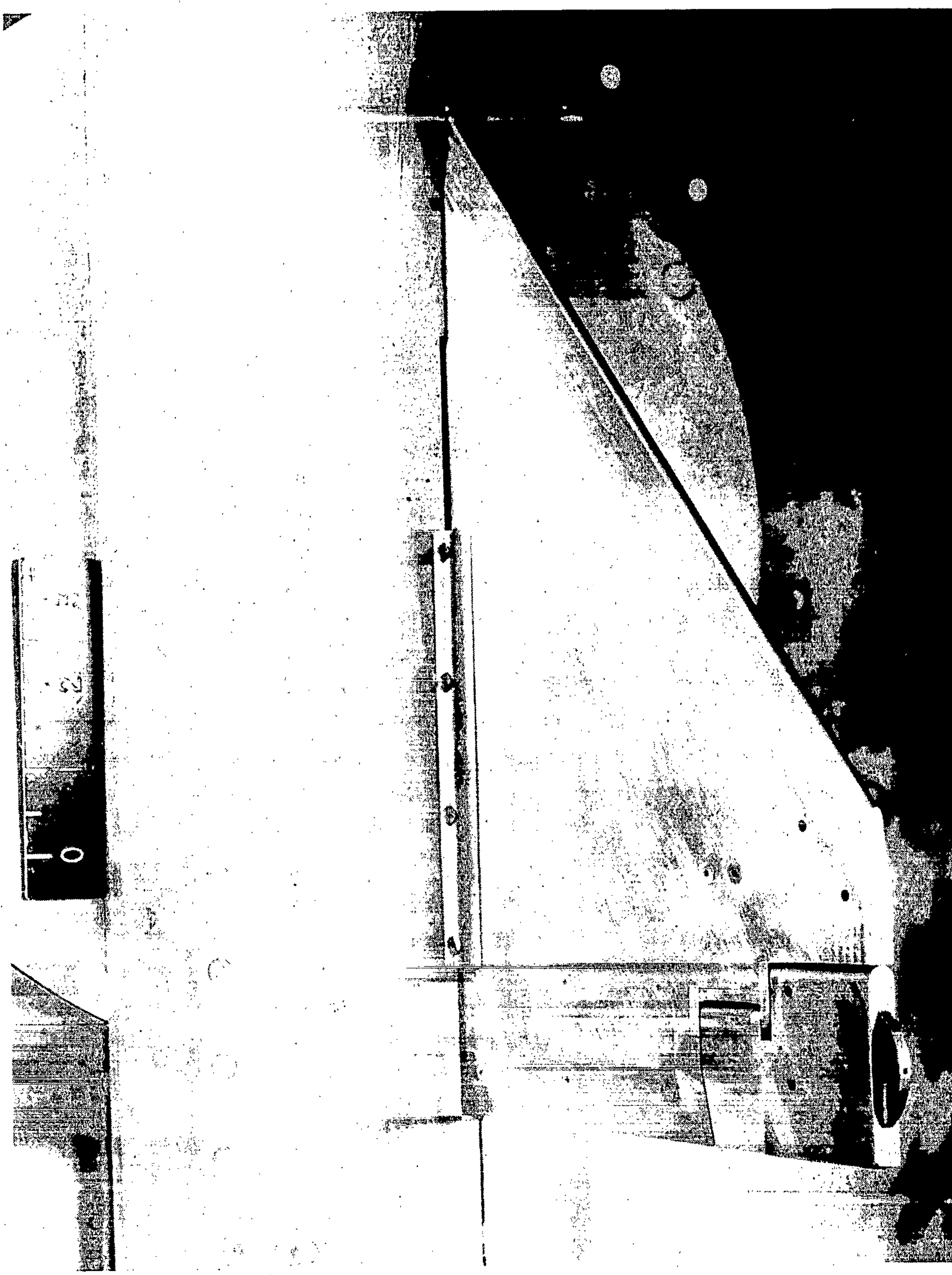
Figure 2.- Details of model. All dimensions are in inches.



Percent balance	Dimensions "A"	"A" + .156
20	1.356	1.512
28	1.160	1.316
36	0.982	1.138

Figure 3.- Details of rollerons. All dimensions are in inches.

Figure 4.- Details of model and boundary-layer bypass plate. L-87452



L-87453

Figure 4.- Concluded.

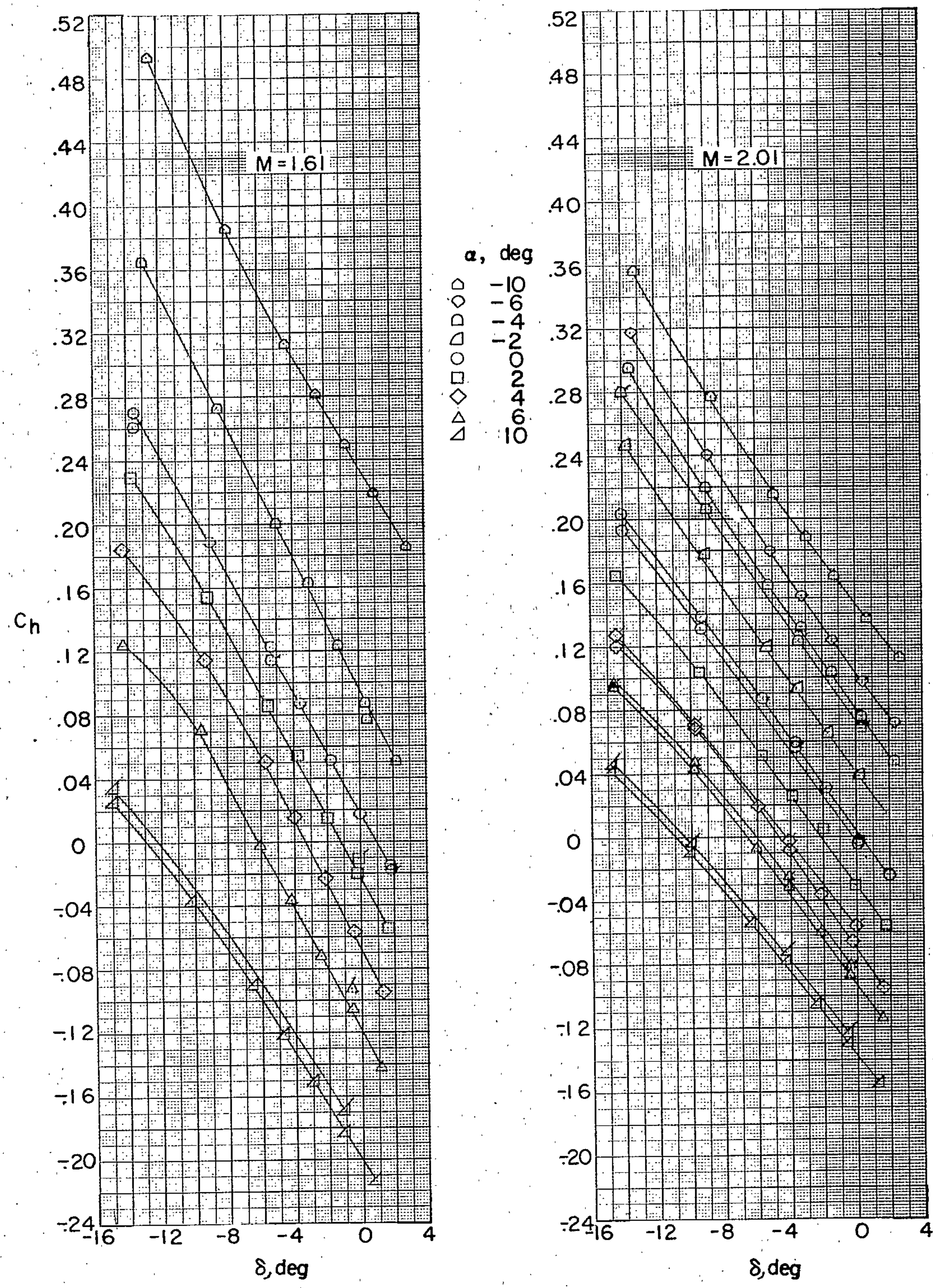


Figure 5.- Variation of the basic coefficients with control deflection for the 20-percent balance control. Flagged symbols denote wheel off.

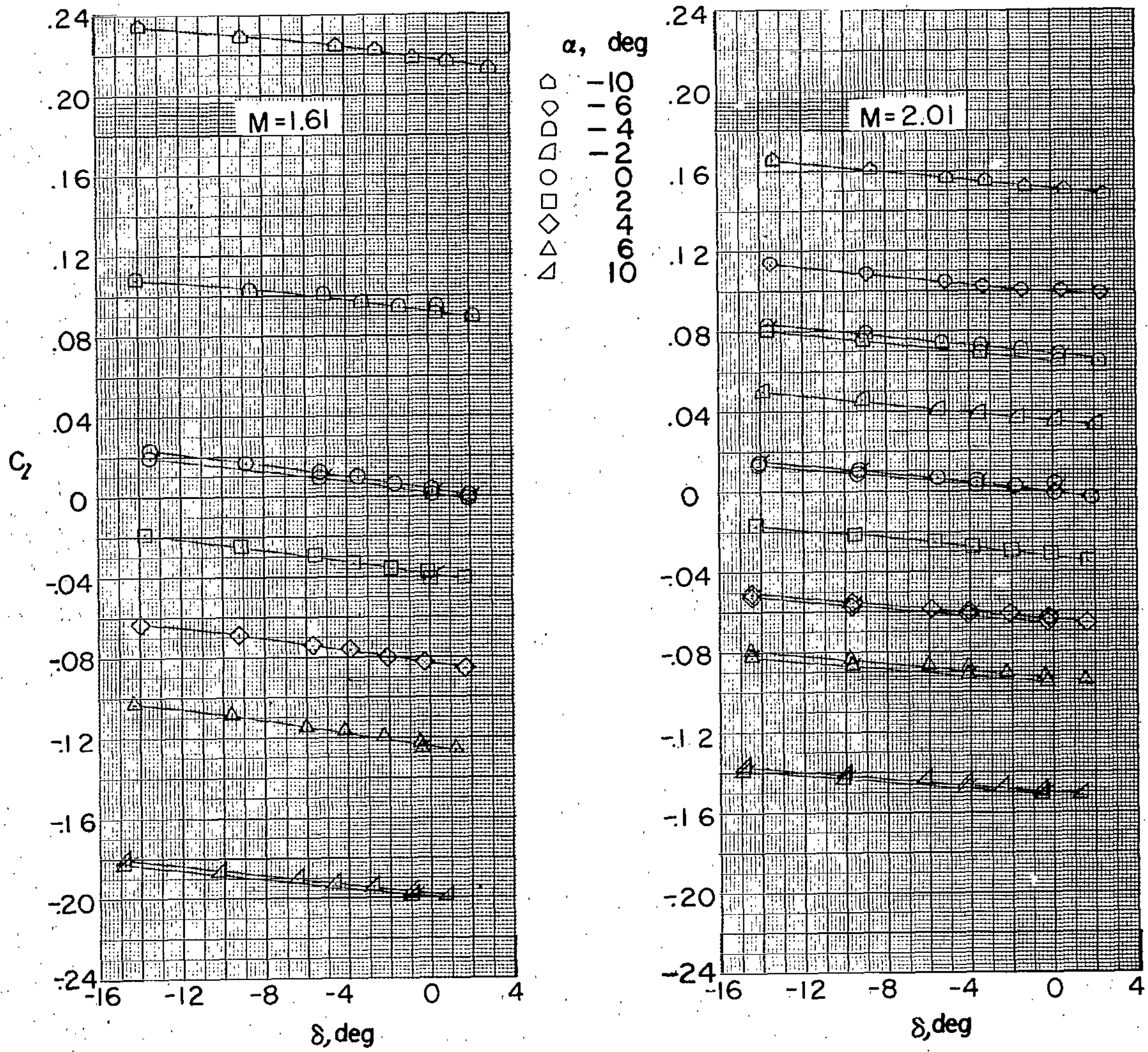


Figure 5.- Continued.

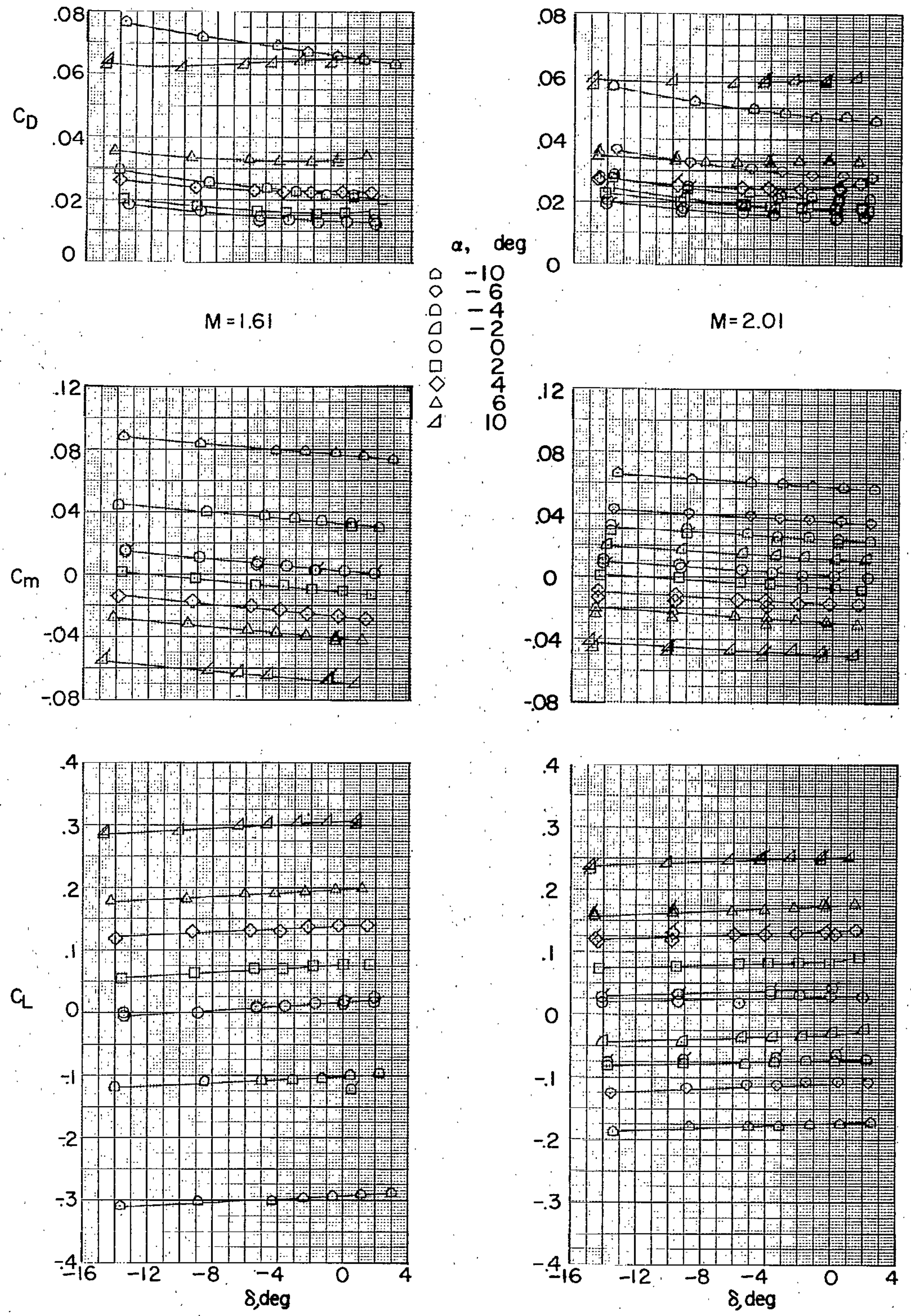


Figure 5.- Concluded.

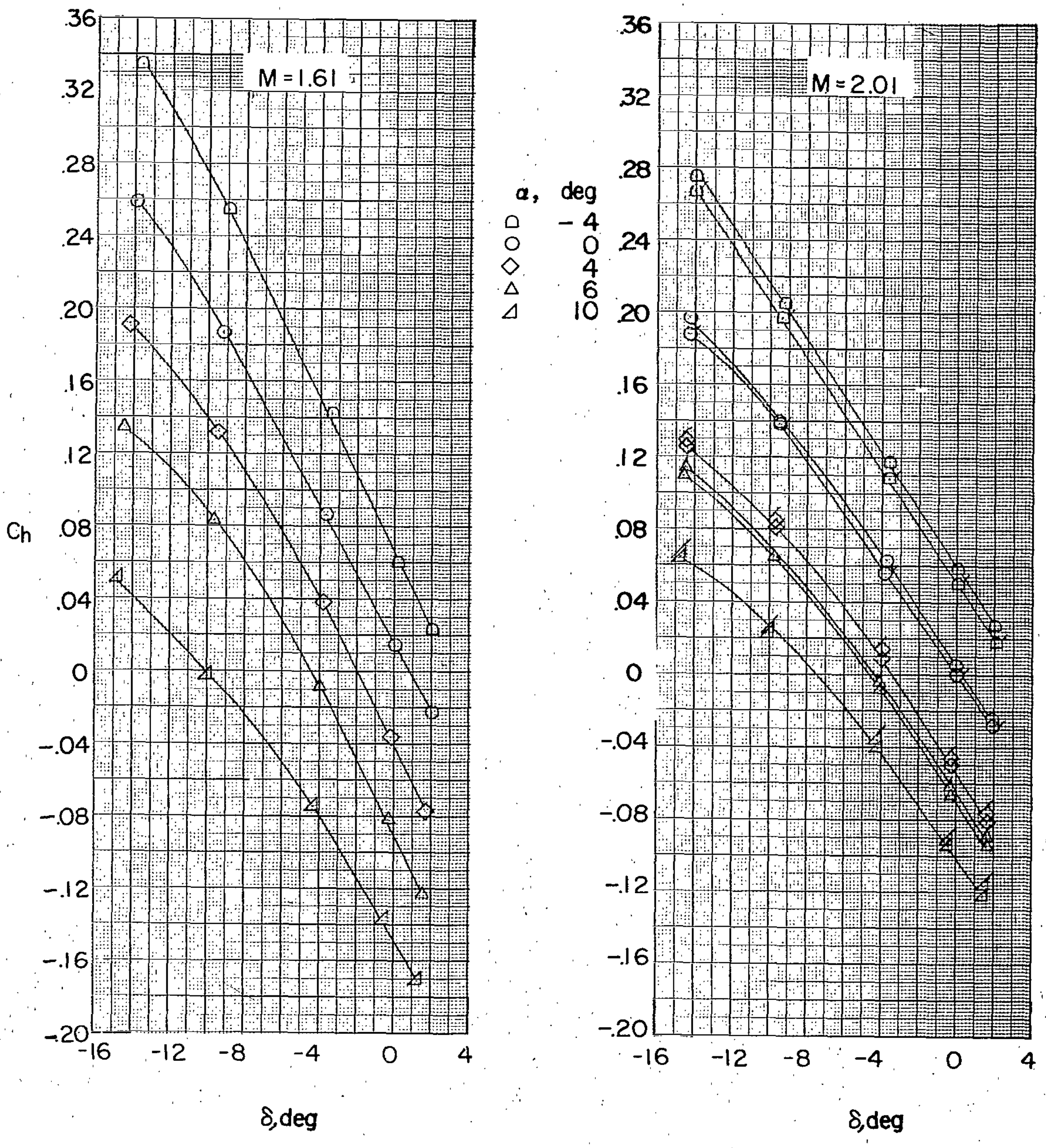


Figure 6.- Variation of the basic coefficients with control deflection for the 28-percent balance control. Flagged symbols denote wheel off.

[redacted]

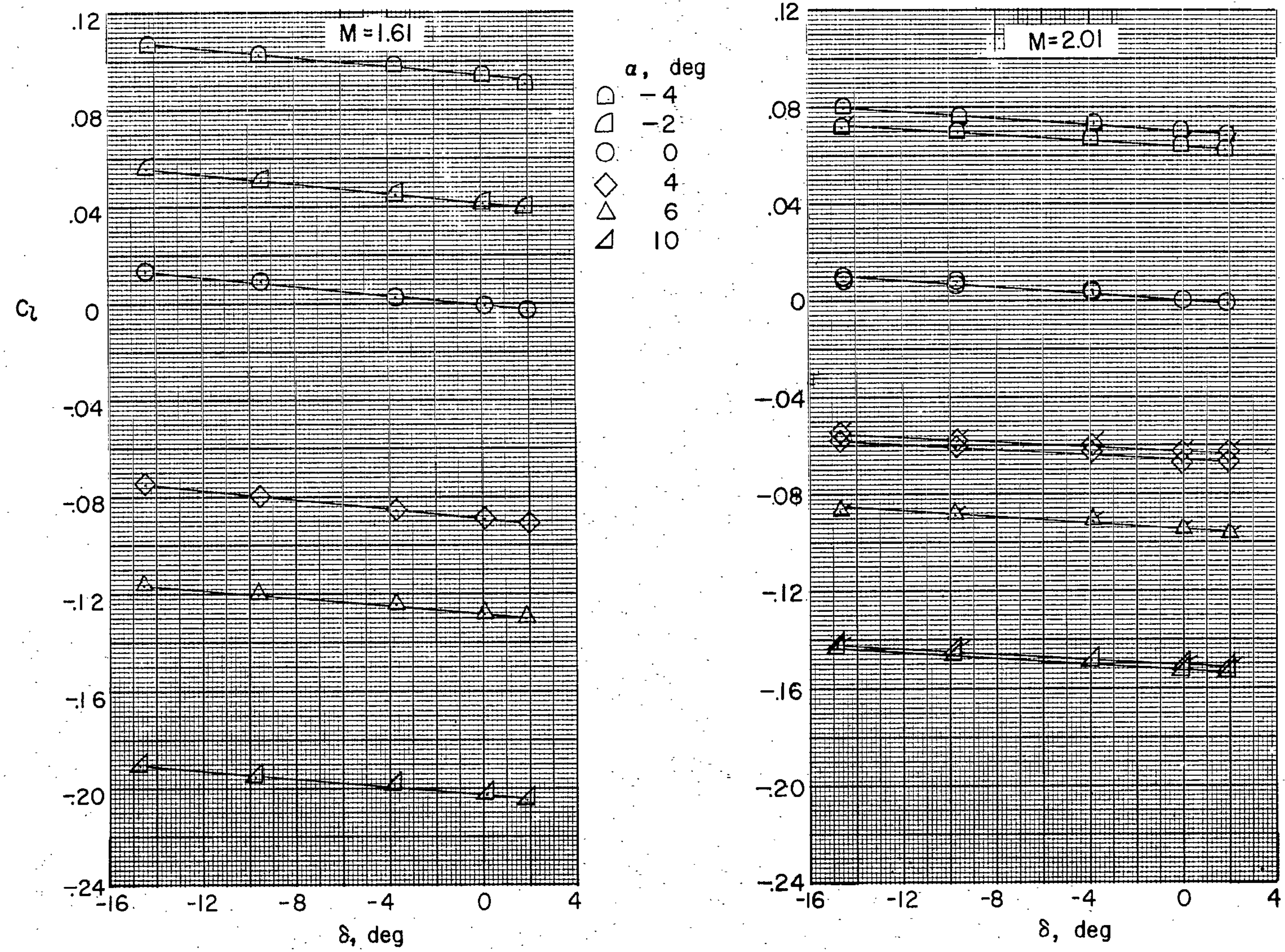


Figure 6.- Continued.

[redacted]

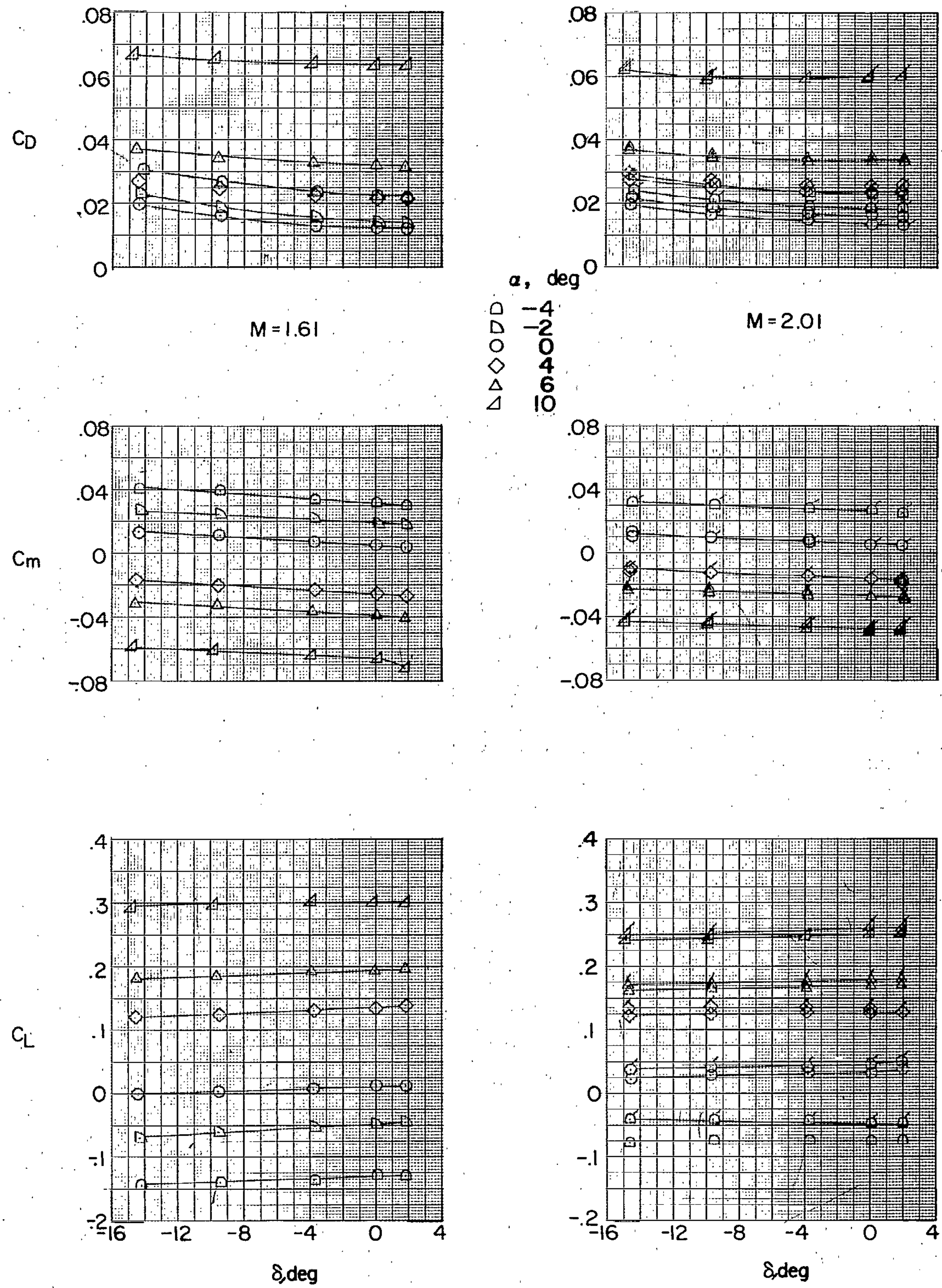


Figure 6.- Concluded.

[redacted]

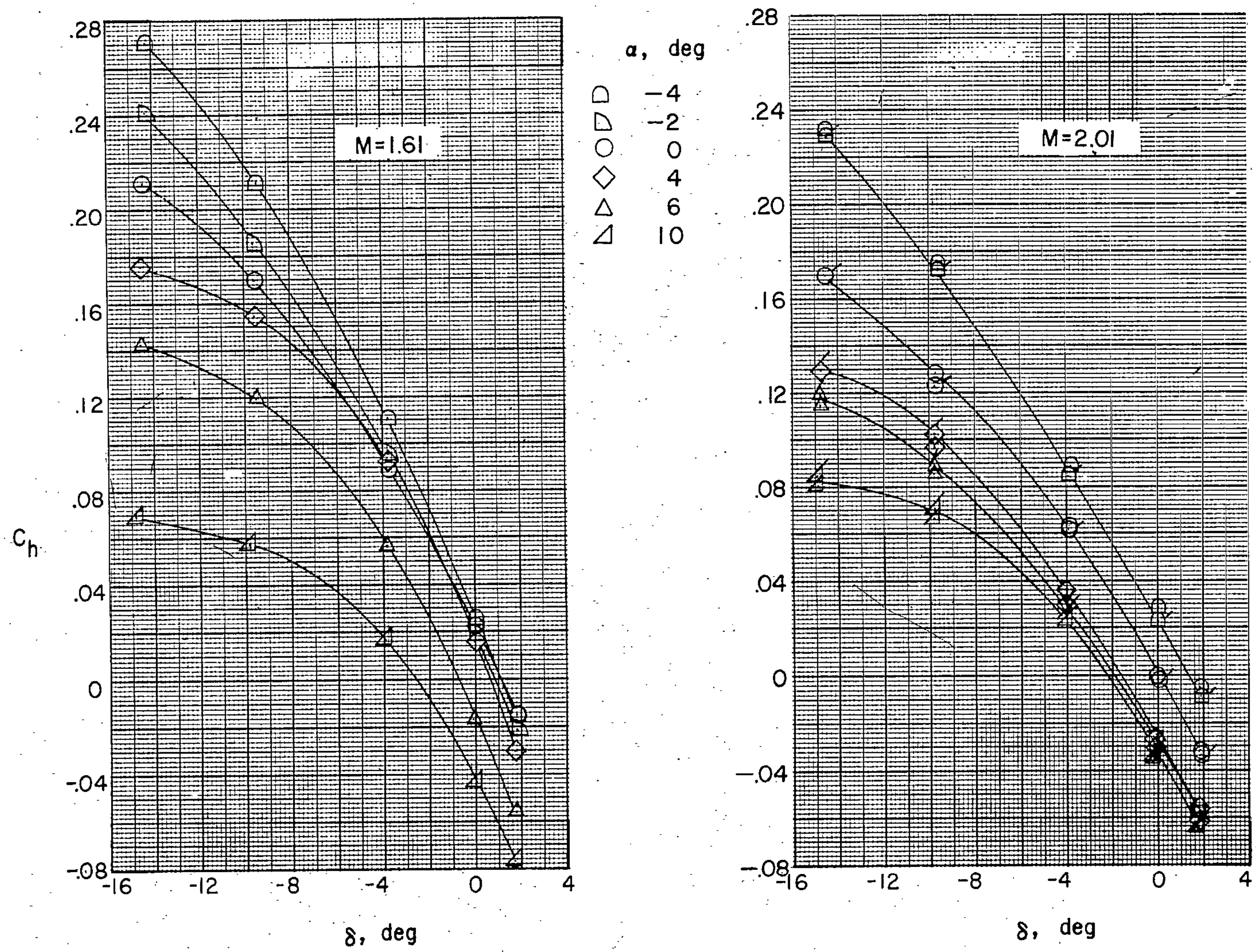


Figure 7.- Variation of basic coefficients with control deflection for 36-percent balance. Flagged symbols denote wheel off.

[redacted]

[redacted]

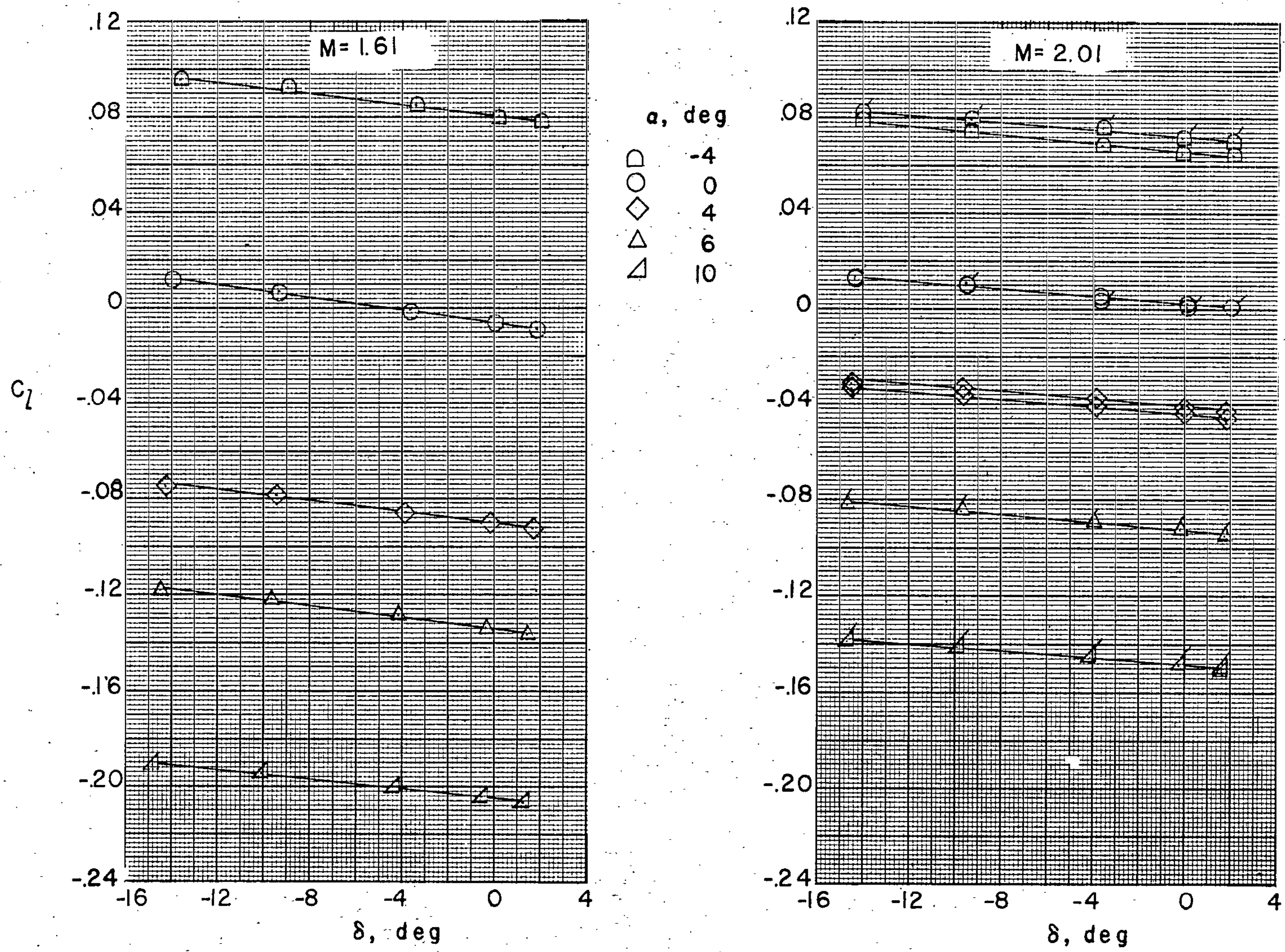


Figure 7.- Continued.

[redacted]

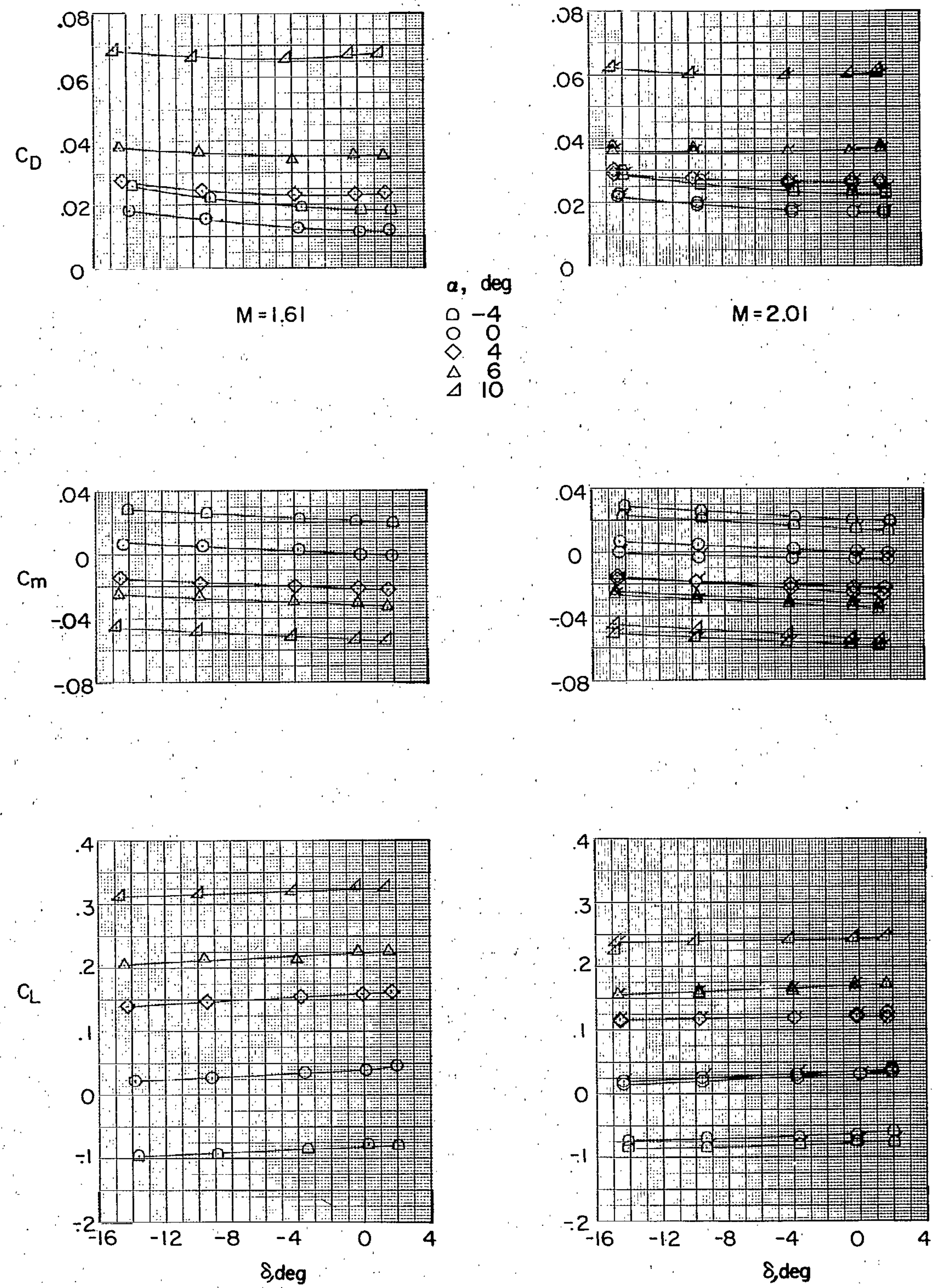


Figure 7.- Concluded.

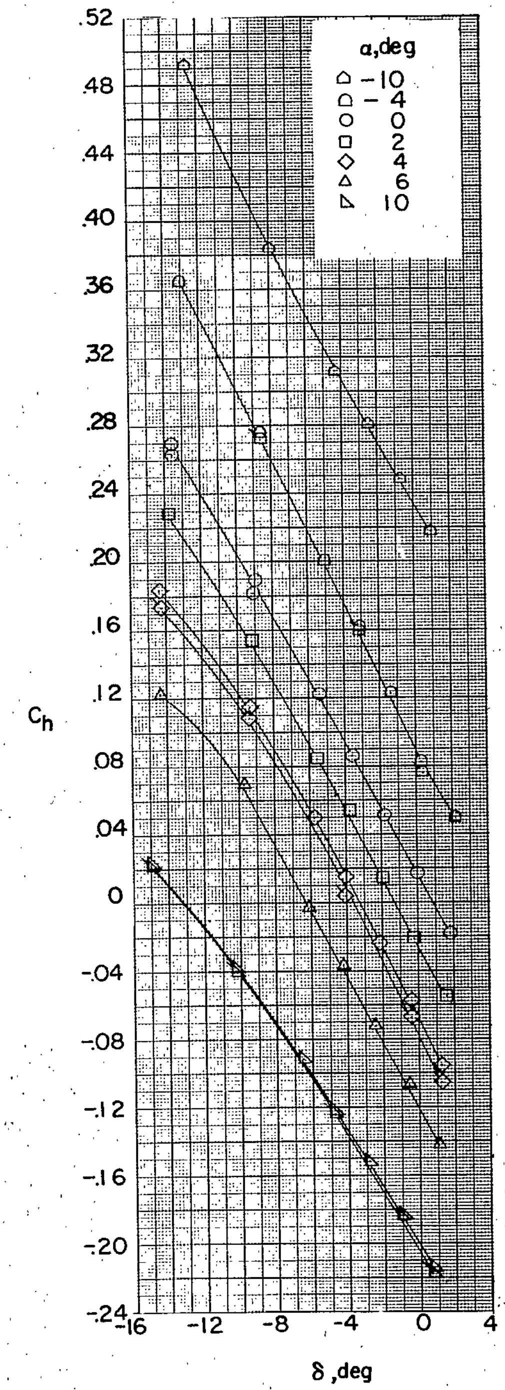


Figure 8.- Variation of the basic coefficients with control deflection for the 20-percent balance control with simulated wing attachment plate installed. Flagged symbols denote attachment plate off; M = 1.61.

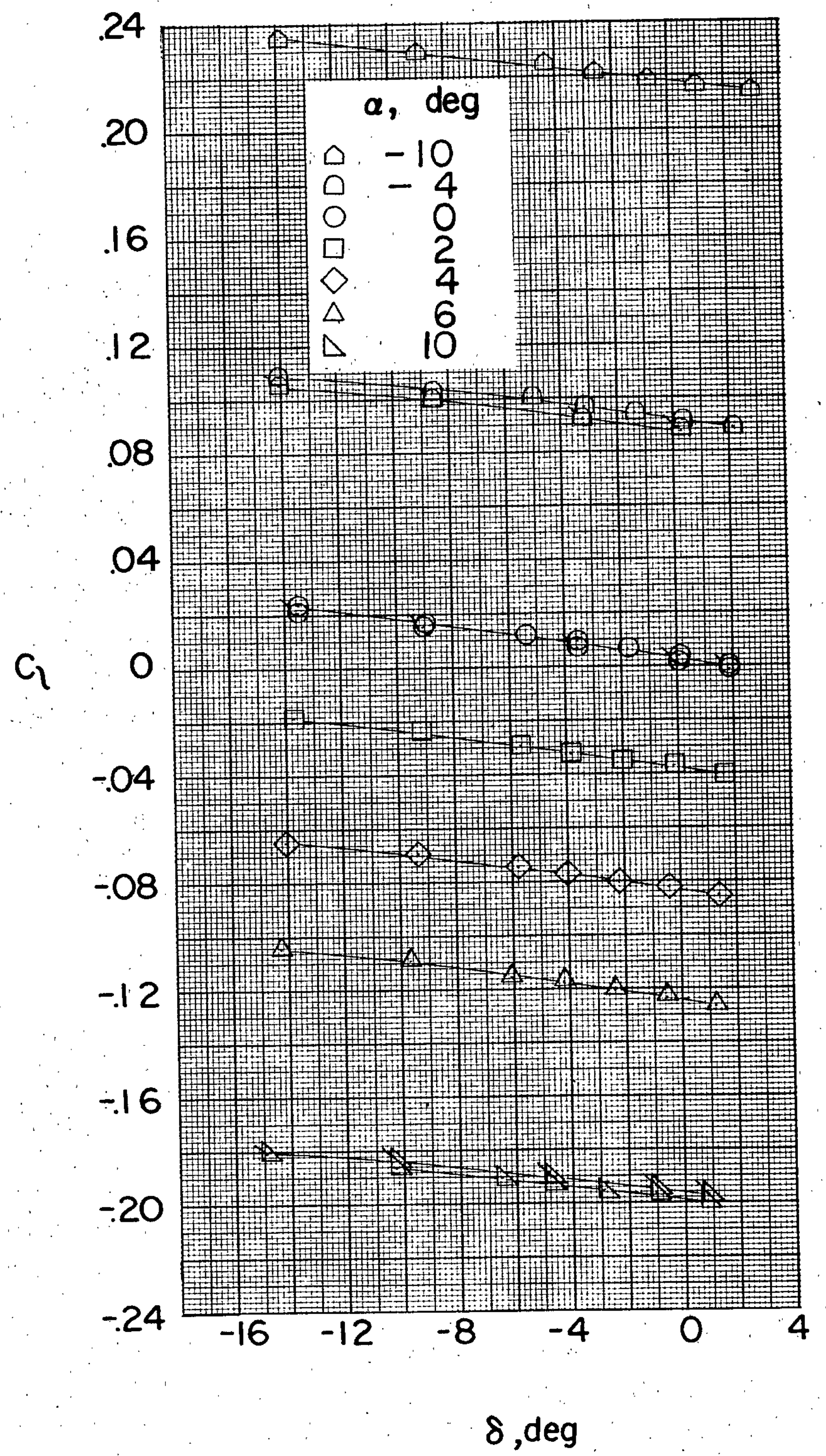


Figure 8.- Continued.

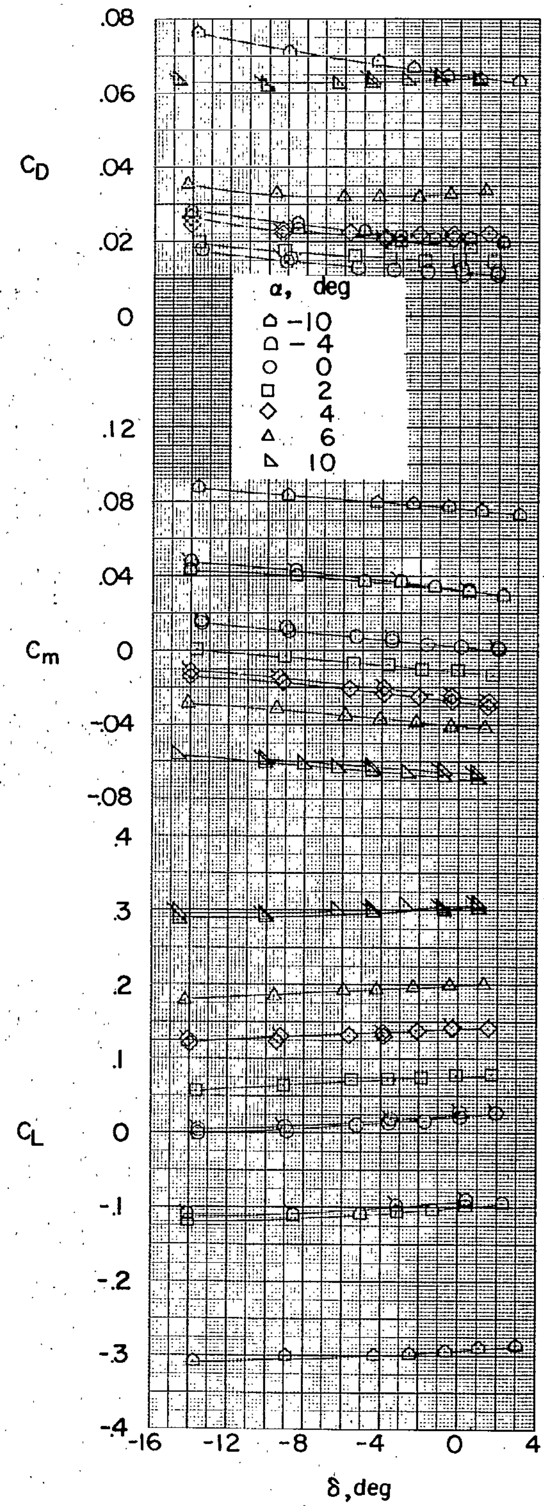


Figure 8.- Concluded.

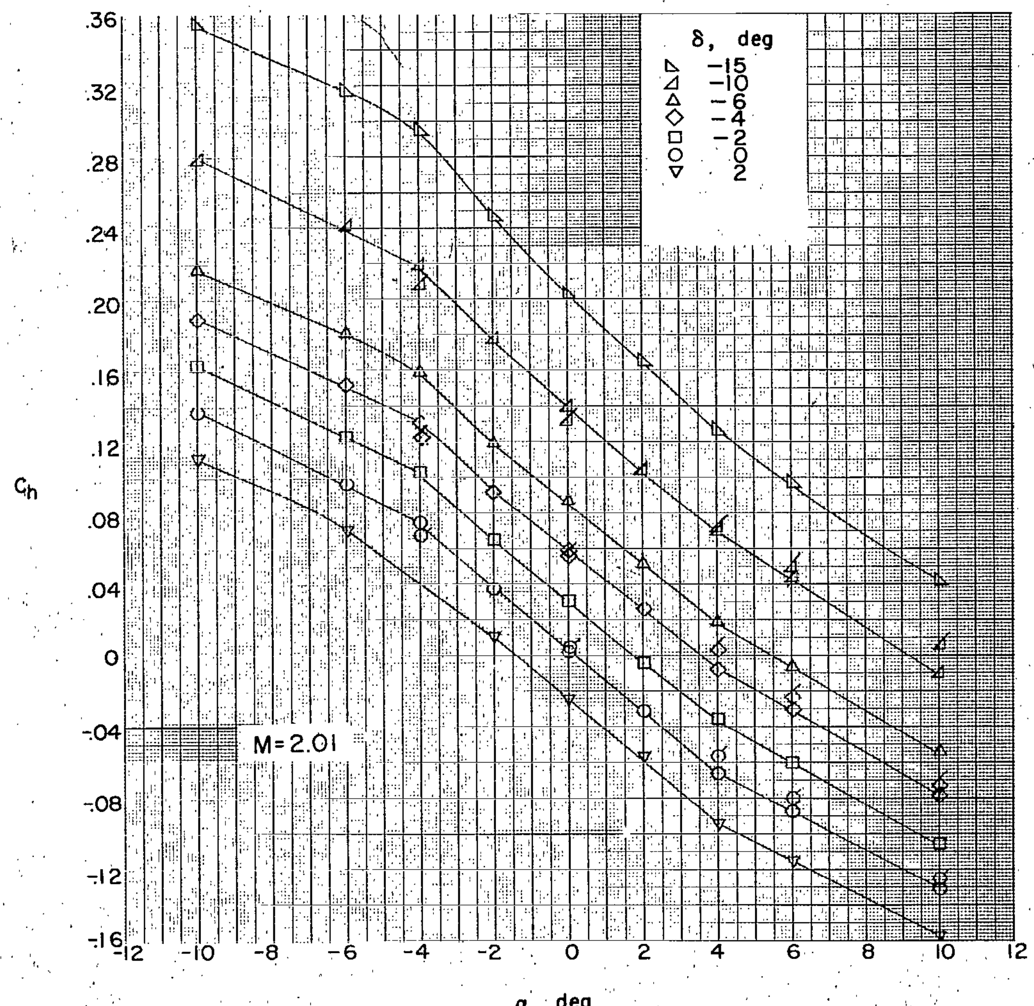


Figure 9.- Variation of hinge-moment coefficient with angle of attack for the 20-percent balance control. Flagged symbols denote wheel off.

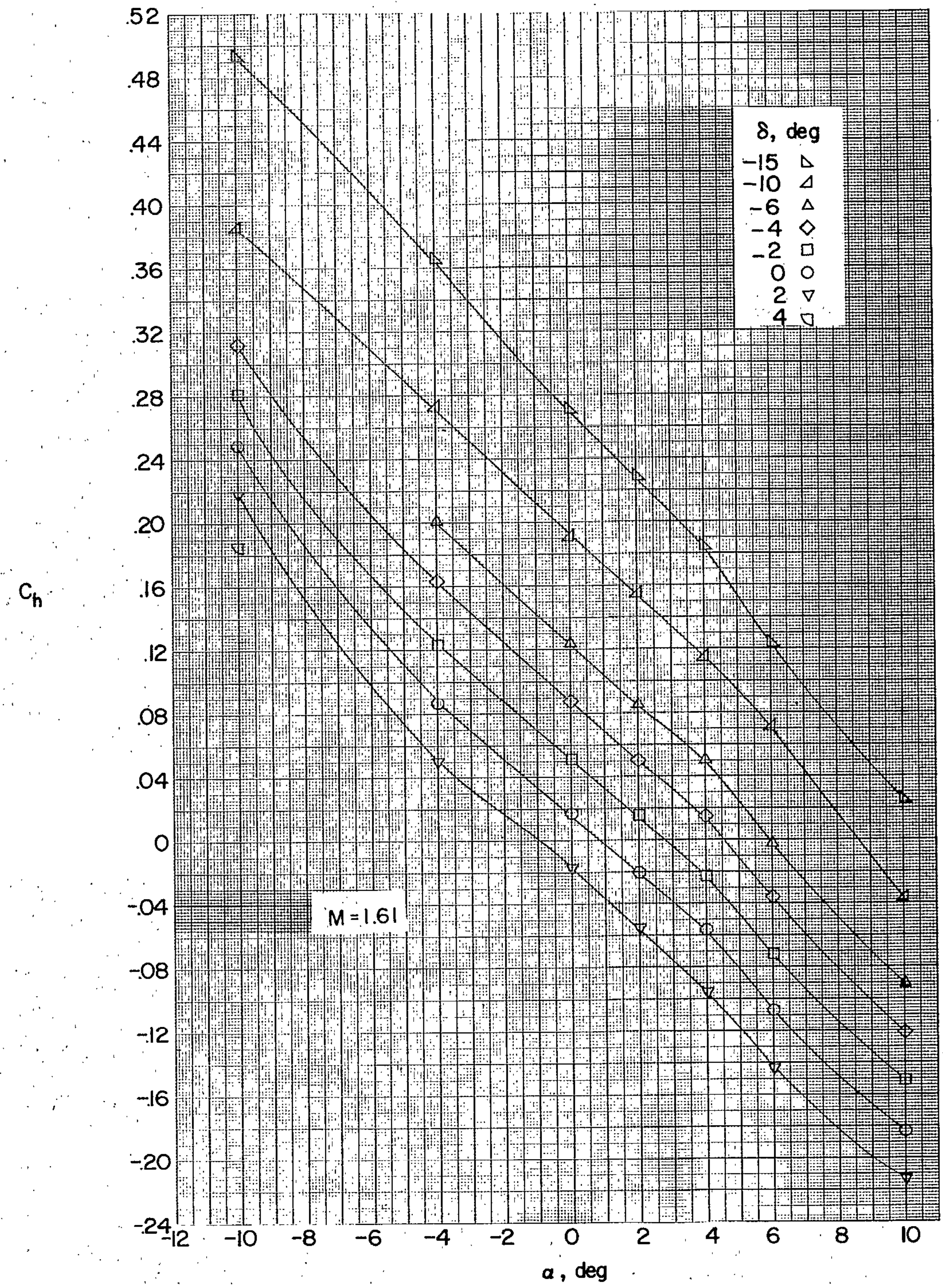


Figure 9.- Concluded.

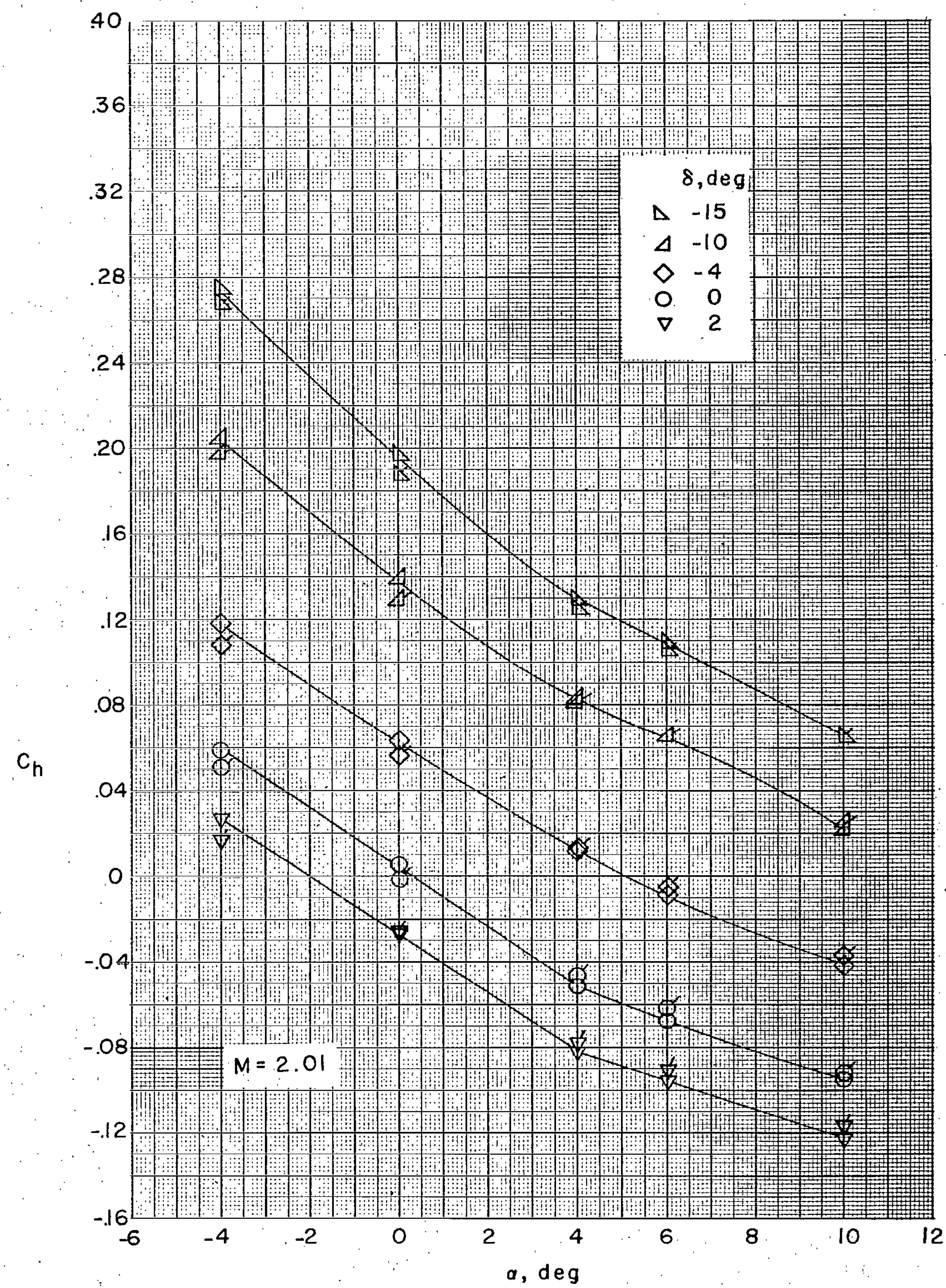


Figure 10.- Variation of hinge-moment coefficient with angle of attack for the 28-percent balance control. Flagged symbols denote wheel off.

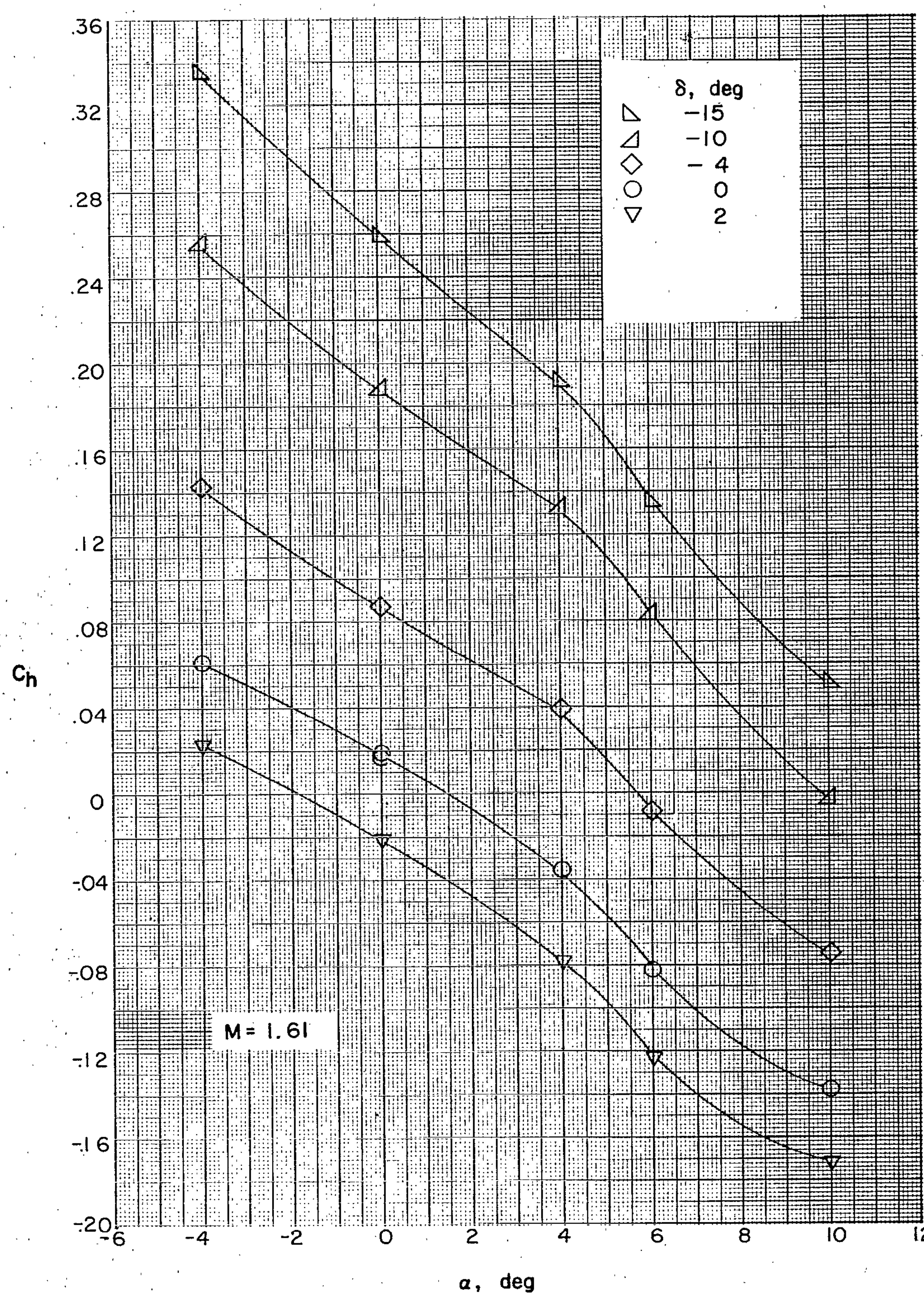


Figure 10.- Concluded.

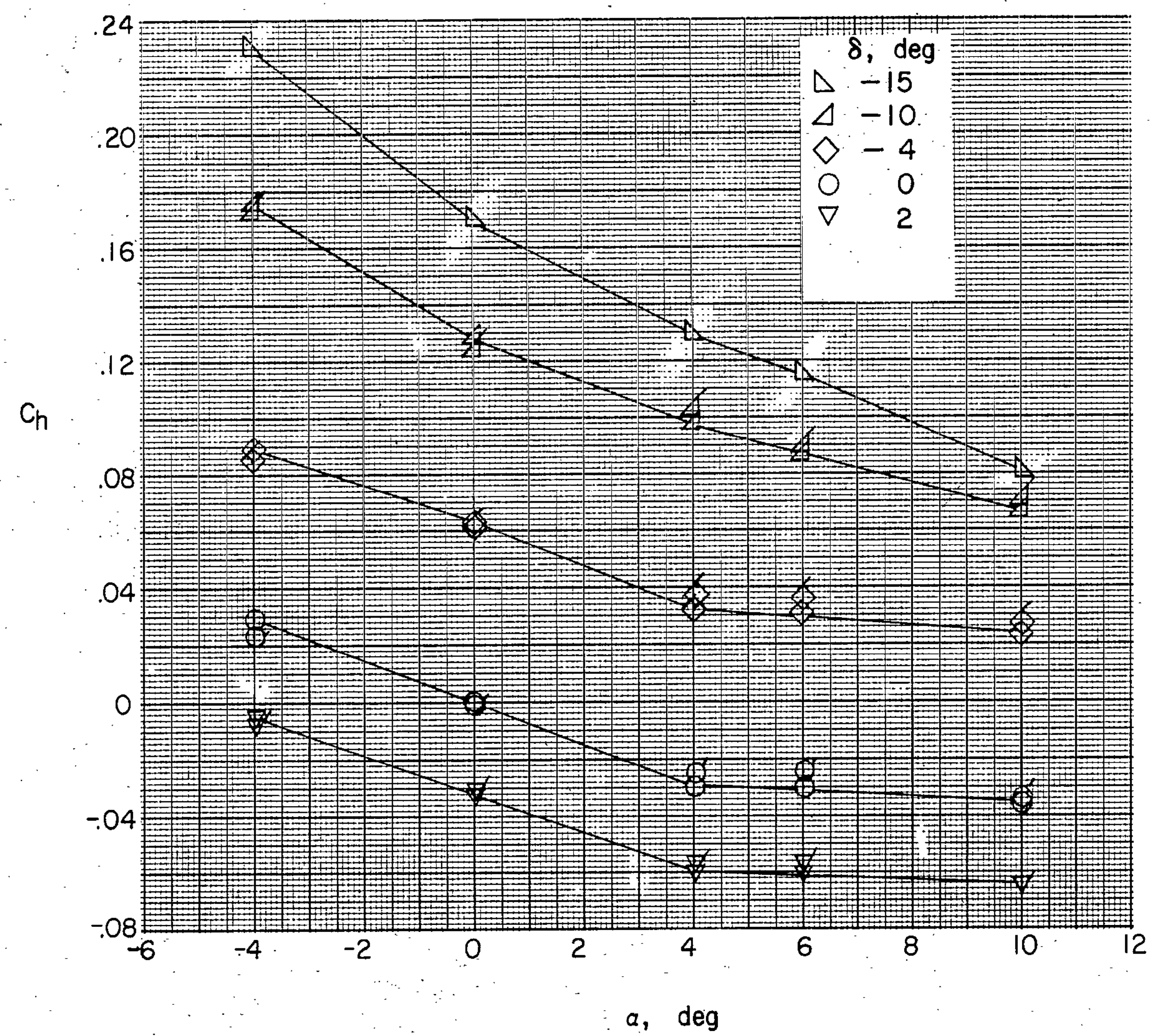


Figure 11.- Variation of hinge-moment coefficient with angle of attack for the 36-percent balance control. Flagged symbols denote wheel off.

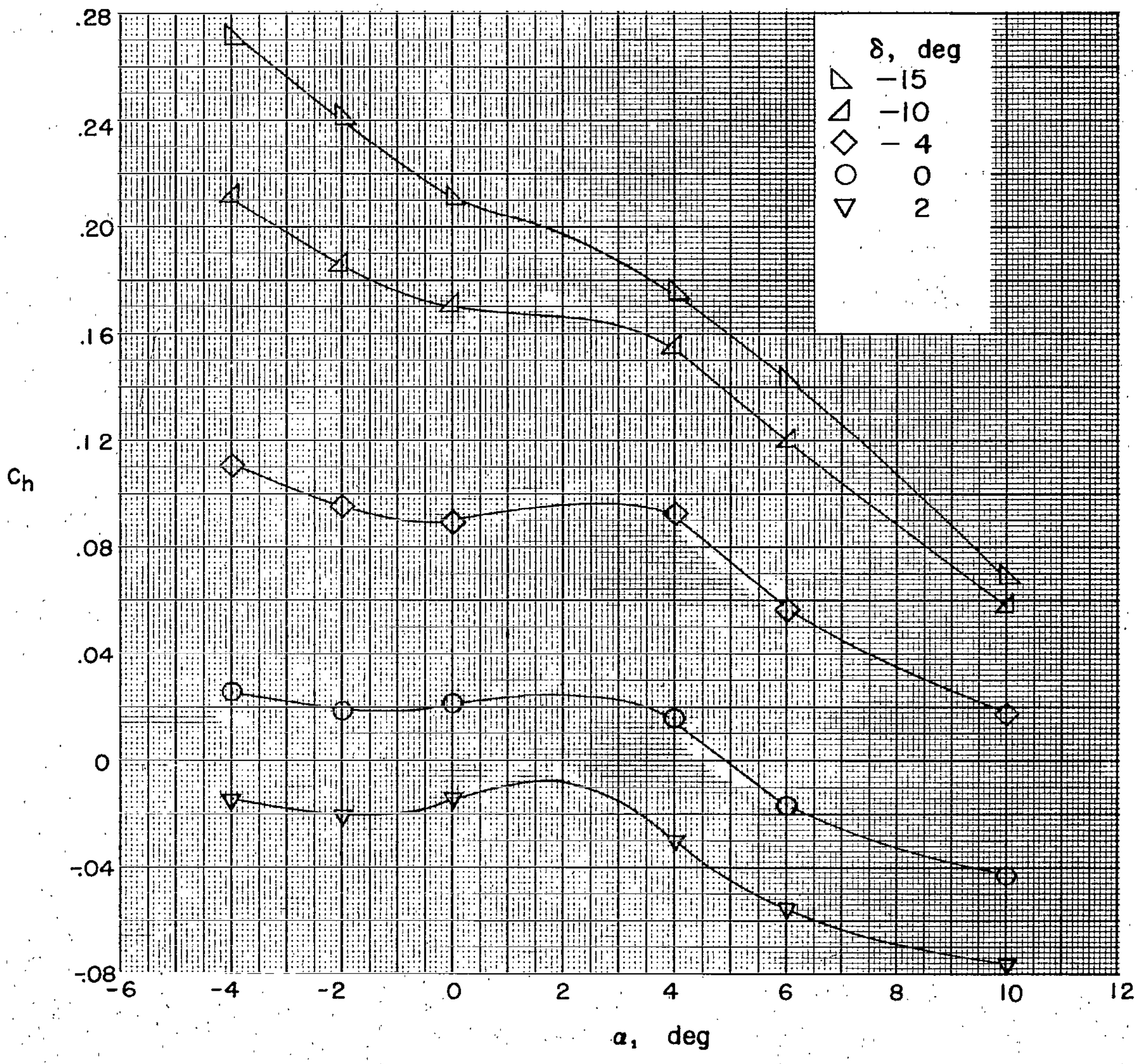


Figure 11.- Concluded.

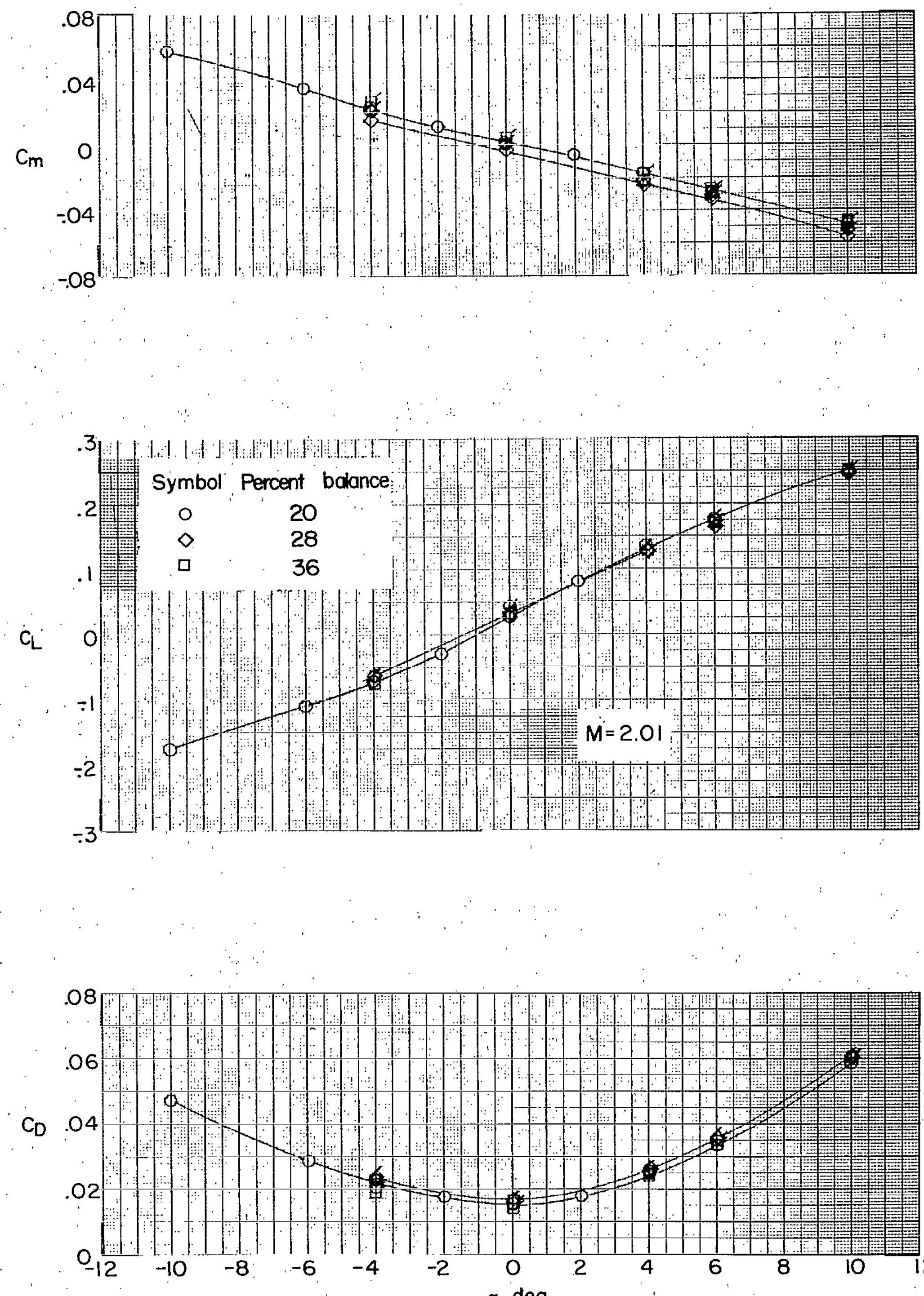


Figure 12.- Variations of wing lift, drag, and pitching-moment coefficients with angle of attack. Flagged symbols denote wheel off; $\delta = 0^{\circ}$.

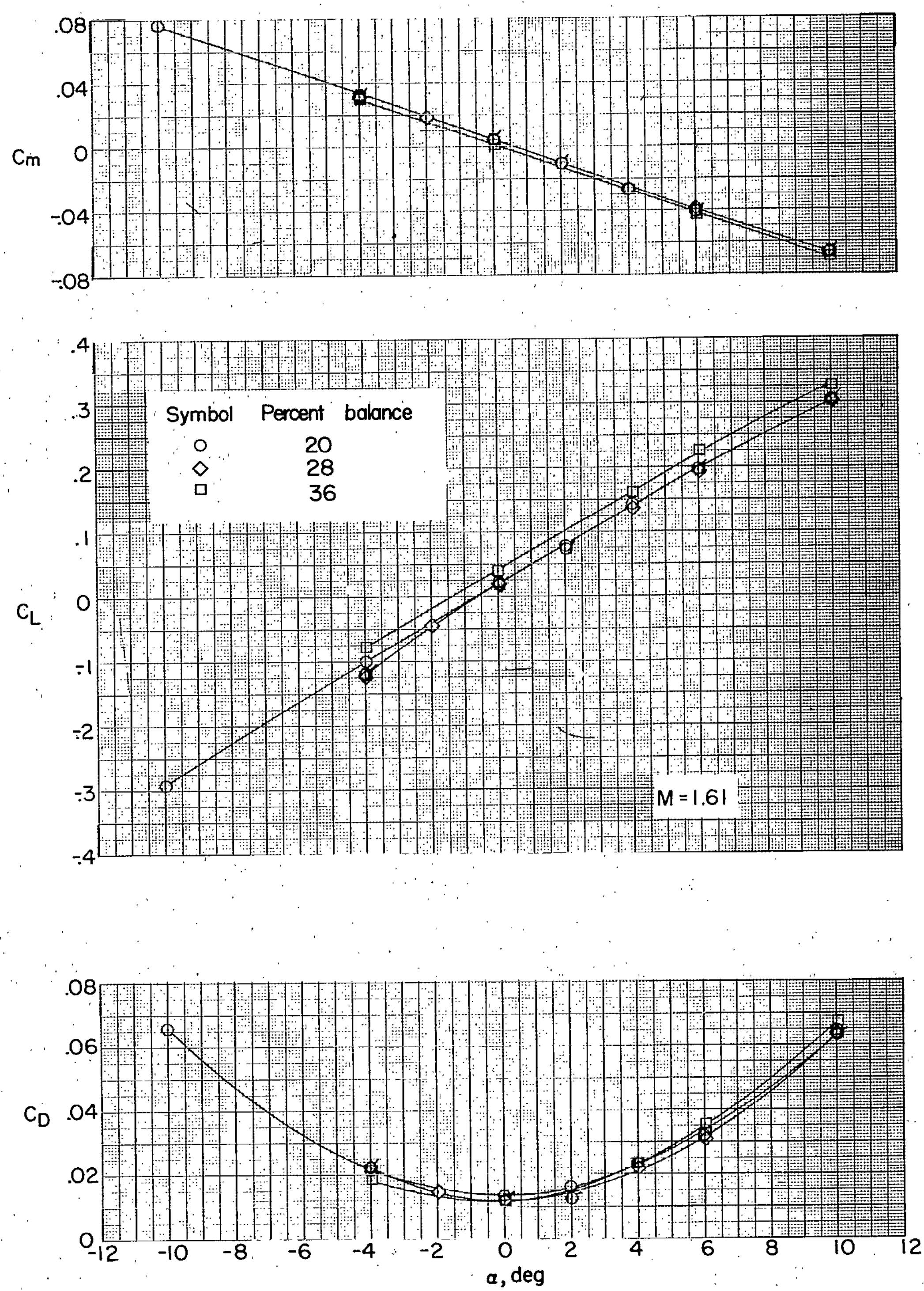


Figure 12.- Concluded.

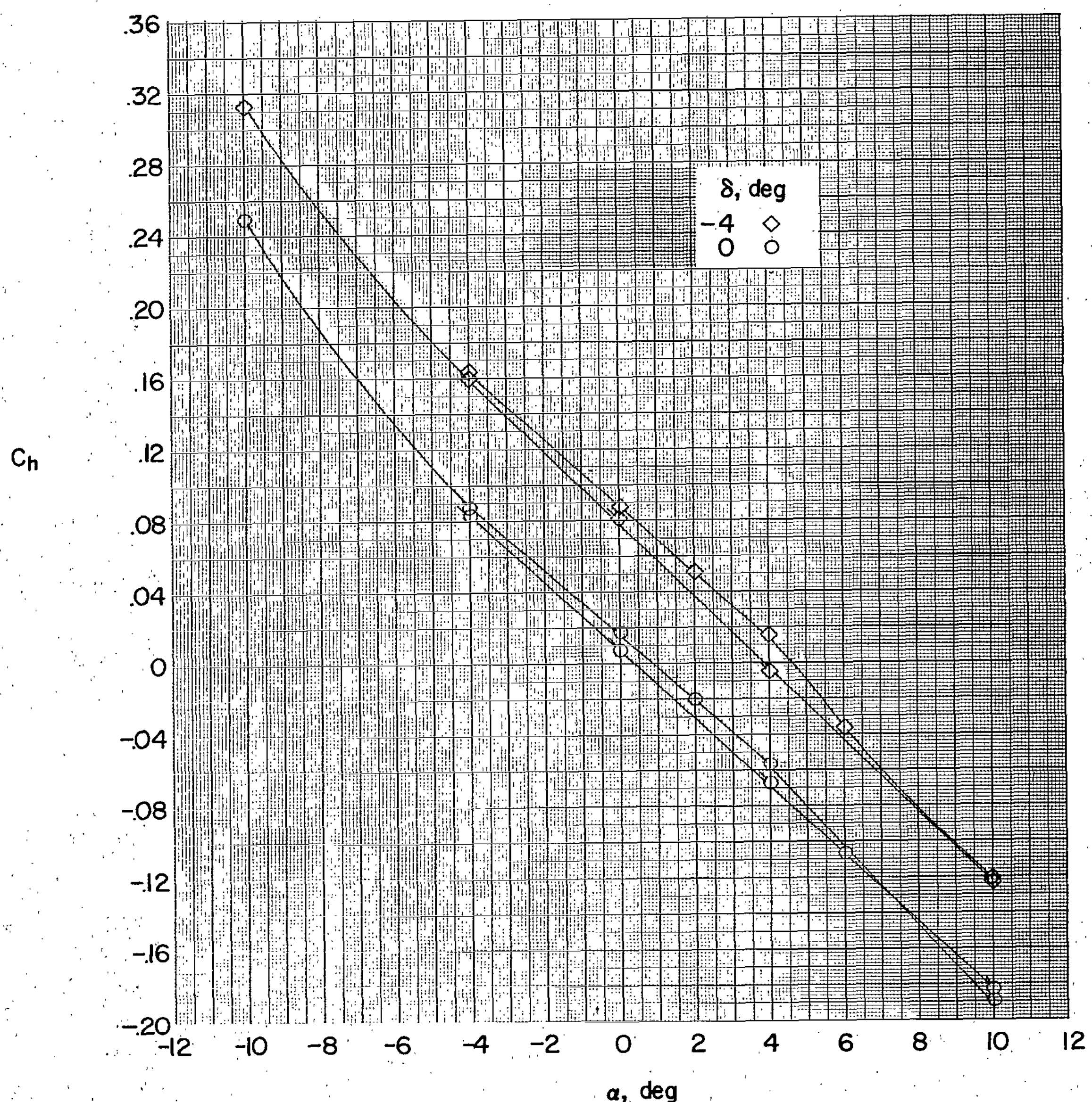


Figure 13.- Effect of the simulated wing attachment plate on the variation of the hinge-moment coefficient with angle of attack for the 20-percent balance control. Flagged symbols denote attachment plate off; M = 1.61.